

**Storm Water Management Model (SWMM)
Analysis Report
Metro West
Fairfax County, Virginia
October 1, 2005**

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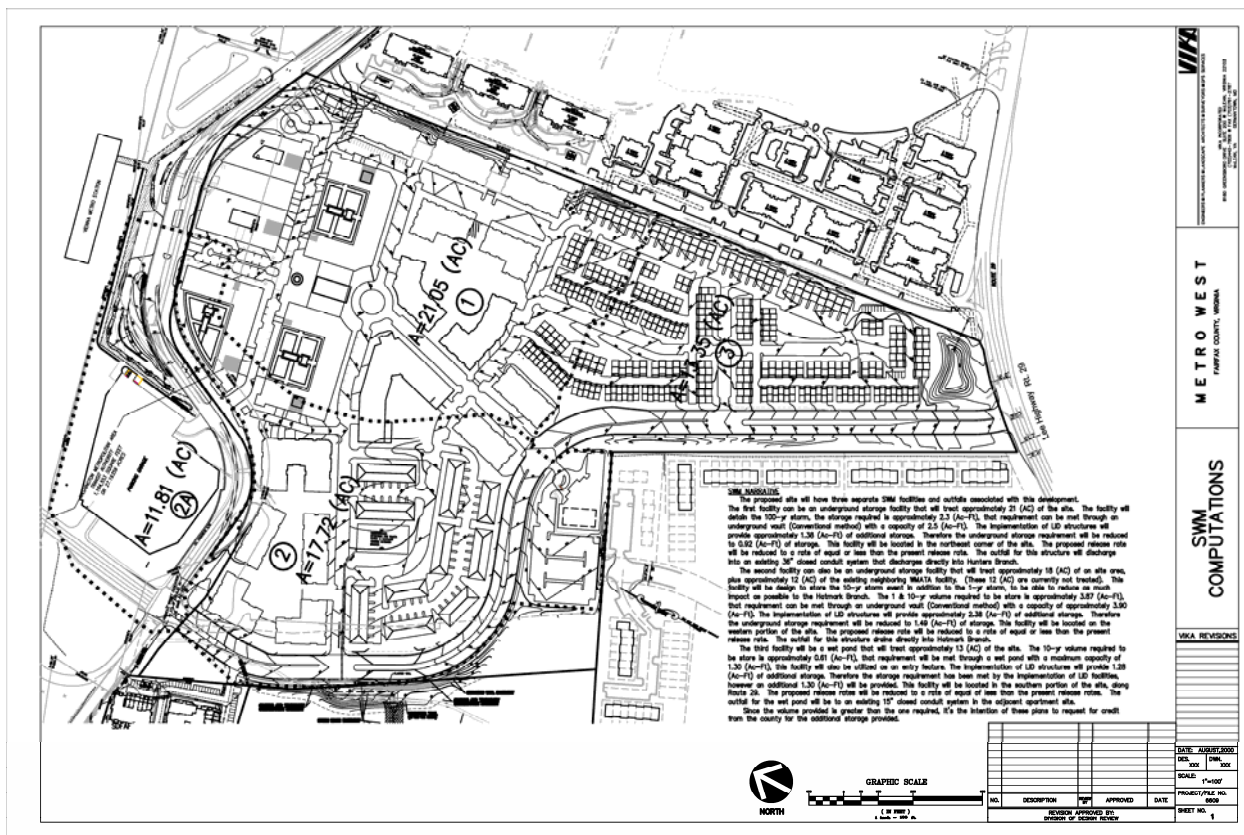
References

I. Executive Summary

The following report is a hydrologic analysis of the proposed Metro West Development project using the USEPA Storm Water Management Model (SWMM) model. The purpose of this study is to determine the effectiveness of the proposed conventional stormwater management (SWM), Best Management Practices (BMPs), and Low Impact Development (LID) and (collectively “SWM/BMP/LID”) in replicating and maintaining the pre-existing (good forested) hydrologic characteristics of the site. The SWM/BMP/LID strategy for the project is focused on maintaining the water balance of the site to the greatest extent possible. The water balance for this project includes the processes of infiltration and groundwater recharge, evapotranspiration, and runoff. The goal is to utilize the combination SWM/BMP/LID practices in an interrelated way to replicate and maintain the pre-existing (good forested) condition of the site and, thereby, reduce peak runoff release rates to below required levels to the greatest extent practicable. This comprehensive approach is designed to help restore the energy balance and stormwater recharge characteristics and not degrade downstream receiving channels.

The SWMM model is a continuous and single event simulation model that is used for long-term simulation of hydrologic and hydraulic conditions. This model can be used to evaluate single-event storms, such as the 2-year 24-hour storm event, or the water balance over the period of a year or more. The study area consists of Four (4) distinct drainage area, or catchments. They are shown in Figure 1.0 and described as follows:

- Drainage Area A is the off-site drainage area to the North from Vienna-Fairfax-GMU Metro Station's. It contains 11.81 acres.
- Drainage Area B is the area on the west of the site that drains to Hatmark Branch. It contains 17.72 acres. The combination of Areas A and B outfall to Hatmark Branch.
- Drainage Area C outfalls at the northeast corner of the development. This drainage area is 21.05 acres
- Drainage Area D outfalls to the southeast corner. This drainage area is 13.35 acres.



Four (4) conditions were modeled for each drainage area. They are as follows:

The criteria for the setup and calibration of the model was based on a guidance document that was developed for Fairfax County (CDM, 2004) for LID SWMM analysis and research on the feasibility of LID in Fairfax County (Kumar, 2005). In order to calibrate the model, a series of 24-hour single storm events (e.g. 1-, 1.5-, 2-, and 10-year) were run using the Natural Resource Conservation Service synthetic unit hydrographs. The results of the peak runoff rates and runoff volume for the Wooded, Existing, and Post Development SWM/BMP condition compared favorably to the analysis run by VIKA Associates that was included in the proffered site plan. The VIKA analysis only included conventional detention SWM and BMP structures, it did not account for the potential effect of the LID features, in order to meet County peak runoff rate requirements. This approach insures that the SWM/BMP/LID strategy will meet County requirements, even if there is some loss of effectiveness of the LID features.

The incorporation LID into the stormwater management strategy is extremely effective at reducing the peak runoff rates for single event storms without the use of additional SWM/BMP measures. Each drainage area within the site contains (Areas A, B, and C) contain approximately Four (4) percent of the surface area in LID practices. Table 1.0 shows the effect of incorporating these practices into the design for each of the drainage areas for the 1.5-year 24-hour storm event. This table shows a reduction in the peak runoff rate of approximately twenty-five percent for each of the on-site drainage areas before it enters the conventional SWM/BMP end-of-pipe systems. For example, Area B has a peak runoff rate of 65.0 Cubic Feet per Second (CFS) using conventional peak runoff rate controls. The incorporation of LID practices reduces the peak runoff rate to 49.0 CFS or a twenty-five percent reduction. This reduction of the peak runoff rate for frequently occurring storm events is significant for channel protection and post-construction erosion control.

Table 1: Peak Runoff Rate Comparison in Cubic Feet Per Second (CFS)

Condition	Area A (CFS)	Area B (CFS)	Area C (CFS)
Proposed without LID without SWM or BMP	49.8	65.0	43.5
Proposed with LID	35.8	49.0	32.2

The LID features will also contribute to further reducing the peak runoff rates above and beyond the effect of the conventional end-of-pipe detention vaults that are incorporated into the design plan. The stage/storage and stage/discharge table from the VIKa study for the stormwater vaults were incorporated into the analysis. The vaults are designed to release the post-development runoff rate at, or below, the wooded condition of the site. The peak discharge rates from the VIKa NRCS methods cannot be directly compared to the SWMM model results. This is because of the different modeling approaches for simulation of the routing through the vaults. The relationships should be similar due to the correlation between the models for the different land use conditions. Table 2.0 is a summary of the comparison of the 2-year 24-hour storm event for the post development condition with and without LID and Table 3.0 is a summary of the comparison of the 10-year 24-hour storm event with and without LID. Although the effects of the LID features are not incorporated in the VIKa analysis it is apparent that there are substantial benefits for peak flow reduction that will result from the incorporation of the LID features.

Table 2: Summary of Peak Discharges from Vaults for the 2-Year 24-Hour Storm Event in Cubic Feet Per Second (CFS)

Condition		Areas A and B (CFS)	Area C (CFS)	Area D (CFS)
Without LID	Inflow	100.5	74.4	48.8
	Outflow	9.5	20.8	11.6
With LID	Inflow	84.0	61.0	36.7
	Outflow	8.5	16.8	6.6

Table 3: Summary of Peak Discharges from Vaults for the 10-Year 24-Hour Storm Event in Cubic Feet Per Second (CFS)

Condition		Areas A and B (CFS)	Area C (CFS)	Area D (CFS)
Without LID	Inflow	178.7	130.7	85.8
	Outflow	60.9	69.7	24.1
With LID	Inflow	147.6	112.4	62.7
	Outflow	47.8	42.4	21.3

As an example, the effect of the incorporation of the LID practices for Drainage Areas A and B, which includes, the Vienna-Fairfax-GMU Metro Station off-site runoff, has a reduction of approximately 10% for the peak runoff rate for the 2-year 24-hour storm event (1 - 8.5 CFS ÷ 9.5 CFS) and approximately 20% for the 10-year 24-hour storm event (1 - 47.8 CFS ÷ 60.9 CFS).

The effectiveness of the LID practices were analyzed using continuous simulation. Hourly rainfall data from Dulles Airport was used to evaluate a representative dry year, an average year, and a wet year of rainfall. A Nine (9) year period of record was also used in the comparison. Table 4.0 compares the Four (4) conditions for each of the drainage areas for 1992 which had a cumulative total of 41.26 inches and can be considered an average rainfall year. Figure 2 is a graphic illustration of the results.

Table 4: Cumulative Runoff Volume for 1992 in Acre Feet (ac/ft)

Condition	Area A (ac/ft)	Area B (ac/ft)	Area C (ac/ft)	Area D (ac/ft)
Wooded	1.3	1.5	3.1	1.6
Existing	21.4	1.8	13.7	8.7
Proposed SWM/BMP w/o LID	21.4	21.5	32.4	22.5
Proposed w SWM/BMP/LID	21.4	16.5	24.1	17.9

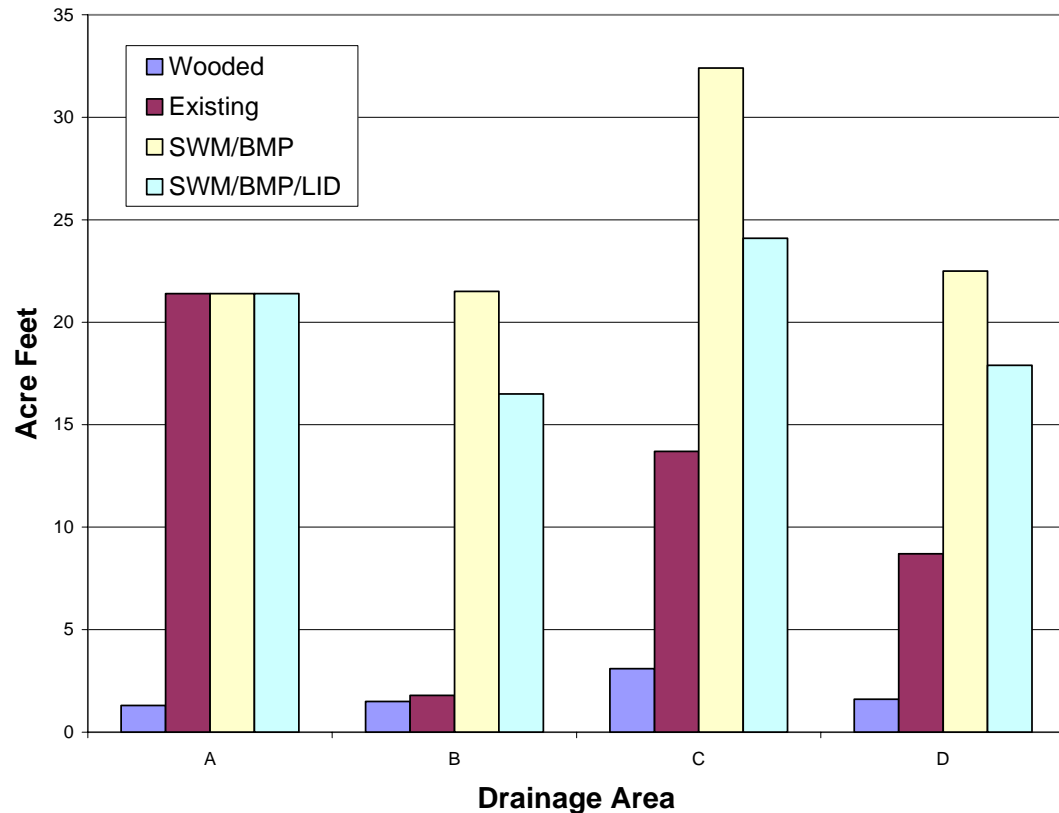


Figure 2: Acre Feet of Runoff for 1992

The results of analysis of Drainage Area C can be used to illustrate the effects of the comprehensive SWM/BMP/LID approach. The 21.05 acre drainage area currently generates approximately 13.7 acre feet of runoff per year. A conventional peak runoff rate detention control (SWM/BMP) approach for the post-development condition would result in approximately 32.4 acre feet of runoff per year, or an average of 1.5 acre feet of runoff per acre ($32.4 \text{ acre feet} \div 21.05 \text{ acres}$). The incorporation of LID controls would result in 24.1 acre feet of runoff. This would be a reduction in runoff of approximately 8.26 acre feet ($32.4 \text{ acre feet} - 24.13$) or approximately twenty five percent ($1 - 24.13 \text{ acre feet} \div 32.4 \text{ acre feet}$) or 0.4 acre feet per acre ($8.26 \text{ acre feet} \div 21.05 \text{ acres}$).

II. Modeling Approach

The following section is a description of the modeling approach that was used to determine the effect of incorporating the LID practices into the SWM/BMP/LID design. This section includes a brief description of the capabilities of the SWMM model, the method for determining the inputs and variables, description of the data set, model calibration, and discussion of the results.

II.1. Overview of SWMM and Modeling approach

The response of the site to precipitation was analyzed using the SWMM model version 5.0. SWMM is a dynamic rainfall-runoff simulation model that is used primarily, but not exclusively for urban areas, for single-event or long-term (continuous) simulation. Flow routing is performed for surface and sub-surface conveyance and groundwater systems, including the option of fully dynamic hydraulic routing in the Extran Block. Nonpoint source runoff quality and routing may also be simulated, as well as storage, treatment and other best management practices (BMPs).

The criteria for the setup and calibration of the model was based on a guidance document developed for Fairfax County (Fairfax County, 2004) for LID SWMM analysis and research on the feasibility of LID in the County (Kumar, 2005). This information was used to primarily address the post-development hydrologic processes of infiltration and flow routing through the LID/BMP/SWM system.

The site was divided into four sub-areas, which are delineated in the AutoCAD file and the related tabular data. The four areas are shown in Figure 3 and the surface condition of each sub-area is summarized in Table 4.

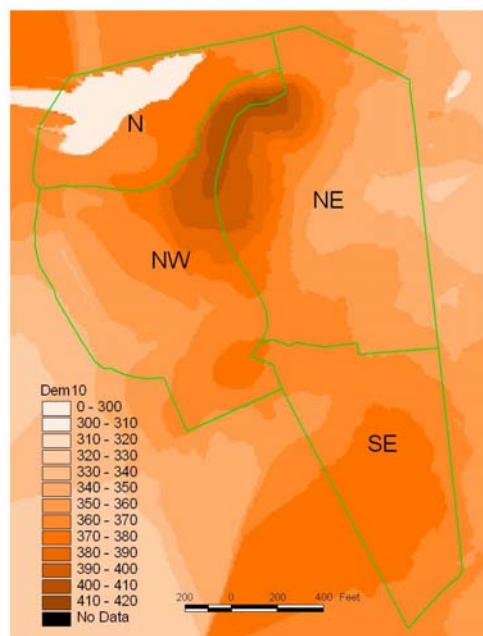


Figure 3 Four Sub-areas for the Site.

Table 5: Summary of four sub-areas (acres)

Sub-area	N	NW	NE	SE	Total
Bldg+Gar	3.64	5.06	7.6	3.43	19.73
Road+Pav	5.18	5.73	6.41	6.34	23.66
Pervious	2.99	6.93	7.04	3.58	20.54
Total Area	11.81	17.72	21.05	13.35	63.93

II.2.Precipitation data

Long-term precipitation data was used as the precipitation inputs for the modeling of the different scenarios. NCDC hourly precipitation data are available at the Washington Dulles International Airport station from October 1966 to October 1993 (NCDC, 1998), but there are some missing years. In order to check the detailed status of the data set, the entire hourly data were rearranged month by month. Eight years do not have complete monitoring data points as shown in the above table. These years are classified as ‘Incomplete’ or ‘n/a’. Before developing this table, the erroneous or flagged data have been removed. Thus, there may be additional missing periods within this data set. Using the precipitation records of the complete monitoring years, average annual precipitation depth (Mean) and the standard deviation (stdev) are estimated. Average annual precipitation depth for these 20 years of precipitation record is about 40.54 inches. Using the average and the standard deviation, each year was classified as “Dry”, “Avg”, or “Wet”. If annual precipitation depth is smaller than the average annual precipitation minus a half of the standard deviation, the year is classified as “Dry”. If the annual precipitation depth is greater than the average annual precipitation plus a half of the standard deviation, the year is classified as “Wet”. Any other years except “Dry” or “Wet”, are classified as “Avg”. Using this approach, seven years were classified as “Dry”; eight years as “Avg”; and five years as “Wet”. The summary is found in Table 6.

Table 6: Table 4.0 NCDC Hourly Precipitation Data Status in inches (in)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Prctp	
1966										1.39	0.45	2.84	4.68	n/a
1967	2.39	3.64	1.86	1.77	4.19	3.25	2.53	7.25	1.35	1.05	1.66	5.22	36.16	Dry
1968	2.49	1.25	4.26	1.35	2.15	2.51	4.06	0.55	2.35	2.12	2.84	3.80	29.73	Dry
1969	1.85	3.55	3.97	2.14									11.51	n/a
1970								0.99	1.20	1.32	2.19	2.66	8.36	n/a
1971	2.19	3.14	2.79	2.69	7.13	1.42	2.45	4.65	5.41	6.86	2.44	1.51	42.68	Avg
1972	3.04	4.87	3.25	4.50	4.80	7.60	2.13	1.72	4.80	3.59	5.16	3.26	48.72	Wet
1973	2.68	4.93	3.11	4.41	3.65	5.98	1.49	8.68	2.37	1.03	1.72	4.46	44.51	Avg
1974	3.96	2.65	3.90	2.00	3.19	3.12	2.71	2.73	1.57	0.61	0.96	3.60	31.00	Dry
1975	5.29	4.16	6.47	2.96	2.01	2.33	4.47	2.37	6.80	5.25	2.83	3.49	48.43	Wet
1976	2.27	1.59	1.49	0.87	2.97	2.41	3.05	8.60	4.40	4.81	1.34	3.00	36.80	Avg
1977	3.02	2.73	2.37	1.57	1.87	4.68	0.72	4.03	1.44	3.76	3.50	8.78	38.47	Avg
1978	6.14	0.98	4.32	3.35	5.22	1.64	6.38	1.31	0.68	3.04	5.06	3.14	41.26	Avg
1979	6.79	5.82	5.48	3.08	8.06	3.70	6.07	4.15	6.79	1.95	5.11	1.65	58.65	Wet
1980	3.57	2.05	4.22	2.78	2.20		3.68		1.82	5.69	2.64		28.65	n/a
1981														n/a
1982														n/a
1983														n/a
1984	3.62	3.38	6.31	4.17	4.61	1.12	3.93	1.94	1.49	1.25	2.08	1.78	35.68	Dry
1985	2.81	3.10	3.00	0.40	4.24	3.81	2.11	8.66	5.63	4.81	5.15	0.89	44.61	Wet
1986	3.88	2.48	0.30	2.08	0.54	1.46	4.66	5.66	3.69	1.18	2.10	4.54	32.57	Dry
1987	6.86	2.00	3.01	2.65	2.56	6.62	3.48	0.67	2.44	3.31	1.80	3.15	38.55	Avg
1988	3.29	3.02	2.14	3.24	2.43	1.63	3.55	2.95	2.92	2.76	2.59	0.52	31.04	Dry
1989	1.51	3.70	6.55	3.54	2.85	3.00	8.25	13.07	6.08	3.66	3.71	1.55	57.47	Wet
1990	3.05	3.41	3.30	3.08	7.23	1.57	5.49	2.60	0.91	2.09	1.74	3.18	37.65	Avg
1991	4.20	0.81	4.47	2.94	0.43	2.24	3.70	7.02	2.52	3.25	0.67	3.28	35.53	Dry
1992	1.74	2.35	3.54	1.52	4.27	2.59	5.19	4.12	5.56	1.39	4.72	4.37	41.36	Avg
1993	3.25	1.45	5.37	2.90	3.99	1.36	0.29	3.49	2.14	4.11			28.35	n/a

Color
legend

Incomplete	8	(yrs)
Dry Year	7	(yrs)
Avg Year	8	(yrs)
Wet Year	5	(yrs)

Total
= 28 (yrs)

Mean	40.54	(in)
stdev	8.09	(in)
M-s/2	36.50	(in)
M+s/2	44.59	(in)

Complete Yrs only

*Note: There are differences in monthly summaries of precipitation between the hourly NCDC dataset (NCDC, 1998) and the NOAA and Virginia State Climatologist website monthly summaries.

- Station Name: WASHINGTON DULLES INTL
- Station ID: 8903
- State: VA

- County: LOUDOUN
- Recording period: 1966 to 1993
- Monitoring resolution: Hourly 0.01 inch data

II.3.Subcatchment set-up for SWMM

The SWMM RUNOFF module was developed using the second method of the Two (2) SWMM modeling methods presented in Section 5.5 of the LID modeling guidance (Fairfax County, 2004). This method is based on modeling a series of Two (2) interconnected subbasins. The first subbasin is the land development area controlled by the LID facilities. The second subbasin represents the total surface area of the LID facilities. The excess runoff from each divide that is not stored, evaporated, or infiltrated through the LID practices is contained in a downstream vault where the runoff is then routed through the structure in order to determine the peak discharge rate of the runoff from the drainage area. The SWMM model was calibrated by conducting a sensitivity analysis between the NRCS Project Formulation Hydrology Technical Release 20 (TR-20) model runs for the 1-, 1.5-, 2-, 10-, and 100-year 24-hour storm events and similar runs for the SWMM model. The SWMM model was primarily adjusted by changing the connectivity of impervious areas. The sensitivity of the models for each year was generally within a range of less than Ten (10) percent, which is an acceptable range. It should be noted that both of these are ungauged and uncalibrated models. Appendix A includes the comparison of the results for the peak discharges.

Four (4) distinct simulation scenarios were developed in order to determine the hydrologic effects of the LID/SWM/BMP design. Figures 4 through 6 show the schematic for the model. A legend of the model inputs are listed in Table 7. Tables 8 through 9 are a summary of the sub-catchment land covers.

1. **Wooded:** The entire area, including the Vienna-Fairfax-GMU Metro Station's property, is modeled as woods in good condition and divided into four subcatchments. The schematic for the model is shown in Figure 4.
2. **Conventional:** This is the site, including the Vienna-Fairfax-GMU Metro Station's property, in its current configuration. The schematic is shown in Figure 5.
3. **SWM/BMP/LID:** This scenario demonstrates the effectiveness of the LID practices independently of the end-of-pipe SWM facilities. The LID system consists of using disconnectivity, bioretention, vegetated roofs, and permeable pavers for the NW, NE, and SE sites. The runoff from Vienna-Fairfax-GMU Metro Station is modeled in its current configuration and is added to Catchment B in order to determine the cumulative hydrologic effect. For modeling purposes the following conditions were used: Twenty percent of the building area drains to road or paved area, Forty percent of road and paved area drains to an outlet, and Forty percent of pervious area has upstream runoff from buildings, road and paved areas, and other pervious areas. Figure 6 is a schematic of the SWMM drainage area inputs for the LID/SWM/BMP options. The modeling results are for the point immediately upstream of the end-of-pipe detention structures.
4. **SWM/BMP/LID with Detention System.** This scenario is used to determine the potential reduction in peak runoff rates that can be expected by the incorporation of the

LID techniques along with the conventional end-of-pipe SWM facilities. The drainage from the LID facilities is routed through the end-of-pipe detention structures in order to demonstrate the peak flow rate reduction for the series of 24-hour storm events.

Table 7: Legend of Schematic SWMM Plan Symbols

NN- North; **NW-** Northwest; **NE-** Northeast; **SE-** Southeast
BD- Building & garage area which drains to Road (RD); **BN-** Building & garage area which drains to Grass area (G2)
RD- Road & paved area which drains to permeable pavers (Pav) or outlet; **RN-** Road & paved area which drains to Grass area (G2)
G1- Pervious area which has no upstream runons; **G2-** Pervious area which has upstream runons from BD, RN, and G1
Pkg- Parking lot in North area; **Pav-** Permeable pavers for LID; **BR-** Bioretention area for LID

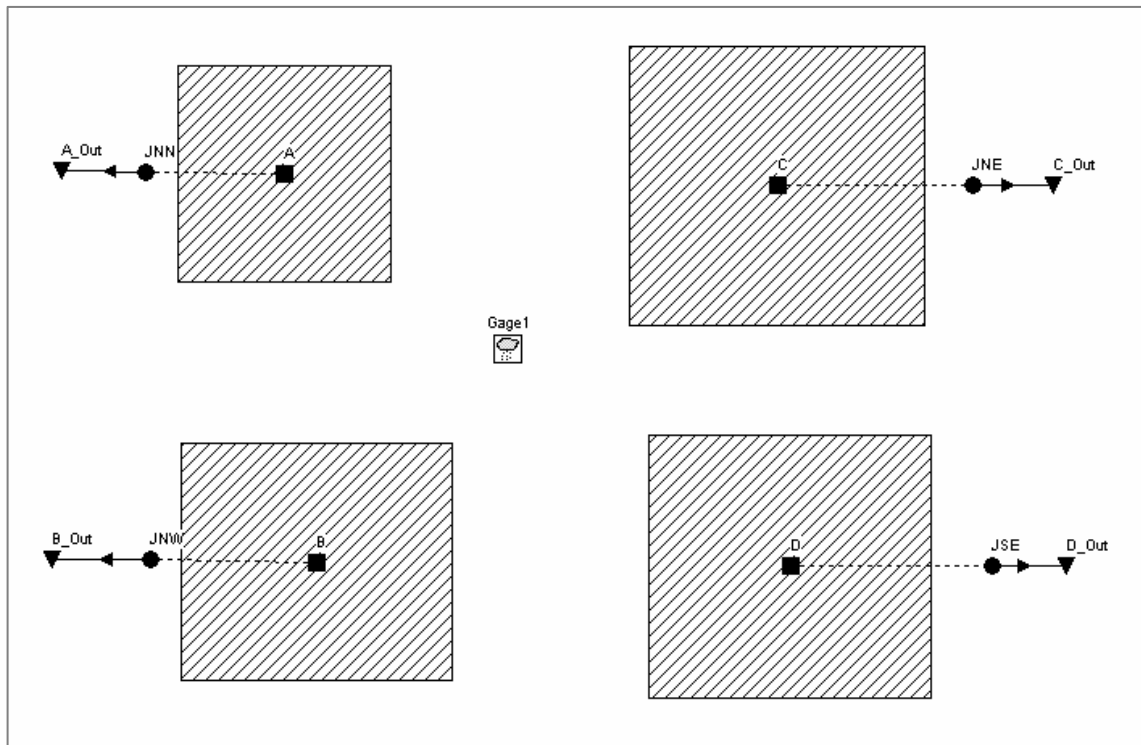


Figure 4: Schematic of Wooded Condition

Table 8: Summary of Wooded Drainage Areas

Subcatchment	Area (ac)
A	11.81
B	17.72
C	21.05
D	13.35

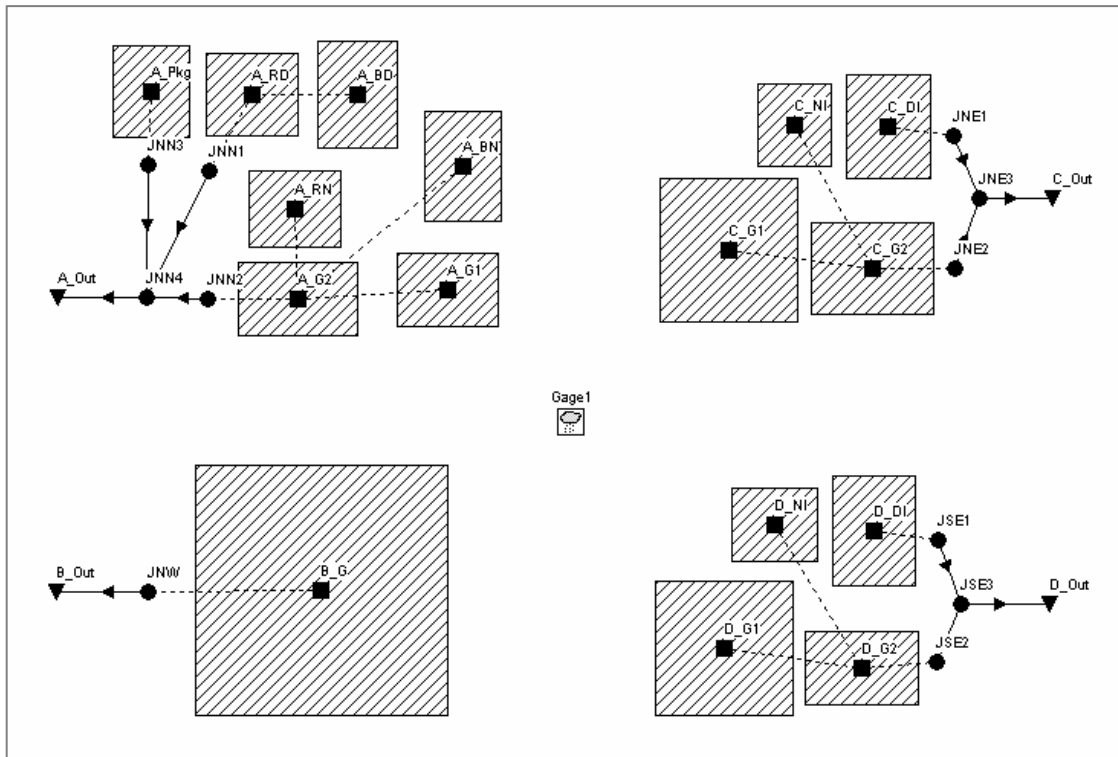


Figure 5: Schematic of Existing Condition

Table 9: Summary of Existing Drainage Areas

Subcatchment	Area (ac)
A_BN	2.366
A_BD	1.274
A_RN	1.554
A_RD	0.726
A_Pkg	2.900
A_G1	2.243
A_G2	0.748
B_G	17.72
C_NI	1.579
C_DI	3.684
C_G1	11.051
C_G2	4.736
D_NI	1.001
D_DI	2.336
D_G1	8.010
D_G2	2.003

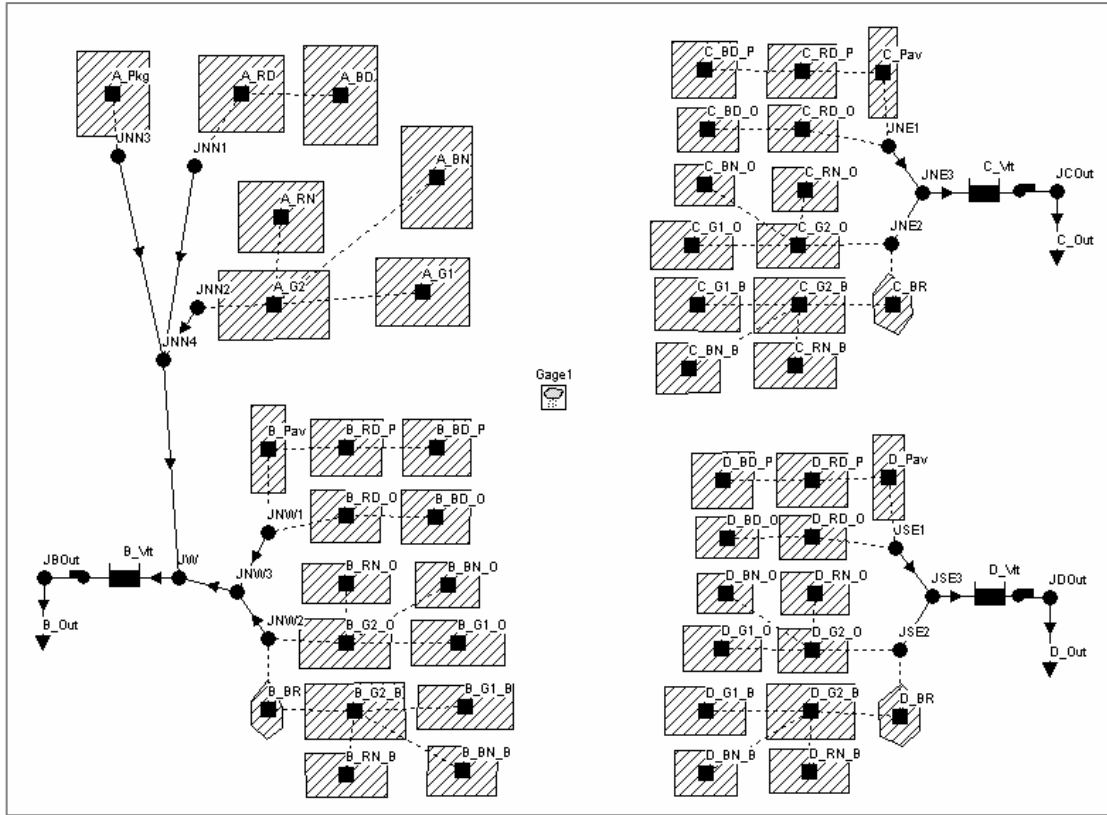


Figure 6: Schematic of Proposed Development

Table 10: Proposed Development Drainage Areas

Sub-catchment	Area (ac)	Sub- catchment	Area (ac)	Sub-catchment	Area (ac)	Sub-catchment	Area (ac)
A_BN	2.366	B_BN_O	2.834	C_BN_O	2.736	D_BN_O	1.646
A_BD	1.274	B_BN_B	0.708	C_BN_B	0.684	D_BN_B	0.412
A_RN	1.554	B_BD_O	1.063	C_BD_O	2.926	D_BD_O	0.960
A_RD	0.726	B_BD_P	0.455	C_BD_P	1.254	D_BD_P	0.412
A_Pkg	2.900	B_RN_O	2.407	C_RN_O	1.570	D_RN_O	2.219
A_G1	2.243	B_RN_B	1.031	C_RN_B	0.673	D_RN_B	0.951
A_G2	0.748	B_RD_O	1.788	C_RD_O	2.917	D_RD_O	2.695
		B_RD_P	0.060	C_RD_P	0.462	D_RD_P	0.241
		B_Pav	0.444	C_Pav	0.788	D_Pav	0.235
		B_G1_O	2.495	C_G1_O	2.534	D_G1_O	1.396
		B_G1_B	1.663	C_G1_B	1.690	D_G1_B	0.931
		B_G2_O	1.663	C_G2_O	1.690	D_G2_O	0.752
		B_G2_B	0.847	C_G2_B	1.070	D_G2_B	0.160
		B_BR	0.262	C_BR	0.056	D_BR	0.341

II.4.Simulation Scenarios

The following section contains a summary of the critical inputs for the hydrologic processes and the results of the different modeling scenarios. Tables 11 through 13 are critical the inputs for surface and subsurface storage and roughness coefficients of the LID systems. The storage for the bioretention includes surface storage and subsurface storage that accounts for a void ratio of 0.4. The storage for permeable pavers includes an accounting for a void ratio of 0.4 also. Soil parameters have been adjusted for the post development condition by decreasing the infiltration characteristics that will result from earth moving and compaction. Each on-site drainage area contains approximately Four (4) percent of the surface area in LID practices.

Table 11: Summary of Land Covers (acres)

Site			A	B	C	D
Location			North	NW	NE	SE
Wooded	All wooded		11.81	17.72	21.05	13.35
Existing	Impervious	Bldgs+Gar	3.640			
		Road+Pav	5.180			
		Total	8.820	0	5.263	5.263
	Pervious	Open+Grass	2.990	17.720	15.787	15.787
Proposed	Impervious	Bldgs+Gar	3.640	5.060	7.600	3.430
		Road+Pav	5.180	5.286	5.622	6.105
		Total	8.820	10.346	13.222	9.535
	Pervious	Pavers		0.444	0.788	0.235
		Open+Grass	2.990	6.668	6.984	3.239
		Bioretention		0.262	0.056	0.341
		Total	2.990	7.374	7.828	3.815

Table 12: Storage and Roughness Coefficients

	Wooded	Building & Garage	Roads & Pavement	Parking Lot	Permeable Pavers	Pervious Area	Bio-retention
DS or Storage (in)	0.3	0.05	0.05	0.05	12	0.15	24
Manning's n	0.25	0.01	0.01	0.01	0.15	0.1	0.15

Table 13: Green-Ampt Infiltration Properties

Soil Type	Loam
Suction Head (in)	3.5
Conductivity (in/hr)	0.1
Initial Deficit (fraction)	0.25

II.5.Discussion of Results

The incorporation LID into the stormwater management strategy is extremely effective at reducing the peak runoff rates for single event storms without the use of additional SWM/BMP measures. Each drainage area within the site contains (Areas A, B, and C) contain approximately Four (4) percent of the surface area in LID practices. Table 14 shows the effect of incorporating these practices into the design for each of the drainage areas for the 1.5-year 24-hour storm event. This table shows a reduction in the peak runoff rate of approximately twenty-five percent for each of the on-site drainage areas before it enters the conventional SWM/BMP end-of-pipe systems. For example, Area B has a peak runoff rate of 65.0 Cubic Feet per Second (CFS) using conventional peak runoff rate controls. The incorporation of LID practices reduces the peak runoff rate to 49.0 CFS or a twenty-five percent reduction. This reduction of the peak runoff rate for frequently occurring storm events is significant for channel protection and post-construction erosion control.

Table 14: Peak Runoff Rate Comparison in Cubic Feet Per Second (CFS)

Condition	Area A (CFS)	Area B (CFS)	Area C (CFS)
Proposed without LID without SWM or BMP	49.8	65.0	43.5
Proposed with LID	35.8	49.0	32.2

The LID features will also contribute to further reducing the peak runoff rates above and beyond the effect of the conventional end-of-pipe detention vaults that are incorporated into the design plan. Appendix A shows the peak runoff rates for the range of NRCS single storm events. The runoff volumes are summarized in Appendix B. The water balance, or evaporation, infiltration, and runoff relationships for the single event storms are shown in Appendix C. The stage/storage and stage/discharge table from the VIKa study for the stormwater vaults were incorporated into the analysis. The vaults are designed to release the post-development runoff rate at, or below, the wooded condition of the site. The peak discharge rates from the VIKa NRCS methods cannot be directly compared to the SWMM model results. This is because of the different modeling approaches for simulation of the routing through the vaults. The relationships should be similar due to the correlation between the models for the different land use conditions. Table 15 is a summary of the comparison of the 2-year 24-hour storm event for the post development condition with and without LID and Table 3.0 is a summary of the comparison of the 10-year 24-hour storm event with and without LID. Although the effects of the LID features are not incorporated in the VIKa analysis it is apparent that there are substantial benefits for peak flow reduction that will result from the incorporation of the LID features.

Table 15: Summary of Peak Discharges from Vaults for the 2-Year 24-Hour Storm Event in Cubic Feet Per Second (CFS)

Condition		Areas A and B (CFS)	Area C (CFS)	Area D (CFS)
Without LID	Inflow	100.5	74.4	48.8
	Outflow	9.5	20.8	11.6

With LID	Inflow	84.0	61.0	36.7
	Outflow	8.5	16.8	6.6

The effectiveness of the LID practices were analyzed using continuous simulation. Hourly rainfall data from Dulles Airport was used to evaluate a representative dry year, an average year, and a wet year of rainfall. A Nine (9) year period of record was also used in the comparison. Table 16 compares the Four (4) conditions for each of the drainage areas for 1992 which had a cumulative total of 41.26 inches and can be considered an average rainfall year.

Table 16: Summary of Cumulative Runoff Volumes for 1992 in Acre Feet (ac/ft)

Condition	Area A (ac/ft)	Area B (ac/ft)	Area C (ac/ft)	Area D (ac/ft)
Wooded	1.3	1.5	3.1	1.6
Existing	21.4	1.8	13.7	8.7
Proposed SWM/BMP w/o LID	21.4	21.5	32.4	22.5
Proposed w SWM/BMP/LID	21.4	16.5	24.1	17.9

The results show that the LID practices reduce the annual runoff volume by approximately twenty-five percent when compared to a conventional detention based approach that does not use LID. For example, a comparison of a LID versus a non-LID option in Catchment D shows a reduction of twenty-five percent (1- 17.9 acres ÷ 22.5 acres). Appendix D contains a summary of the annual water balance for average, wet, and dry years and a period of record using the SWMM model.

This analysis is set up as a “lumped” model. This means that the effects of the individual practices are lumped into a single effect for each catchment. This approach is appropriate due to the scale and context of the hydrologic analysis issues. Studies in Portland (Adderly, 2000) and Washington, D.C. (LID Center, 2003) have modeled and routed each individual practice within a catchment. The results of these models show an even greater reduction in volume and peak. The Portland study was calibrated by monitoring the flows through the system. Based on that experience, it can be anticipated that the LID practices can have a more significant effect on peak and volume reduction than is shown in this modeling effort.

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